99-91255

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 866 551 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.09.1998 Bulletin 1998/39

(51) Int. Cl.6: H03H 9/02

(21) Application number: 98104212.0

(22) Date of filing: 10.03.1998

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 21.03.1997 JP 68370/97
24.03.1997 JP 69620/97
02.07.1997 JP 177144/97

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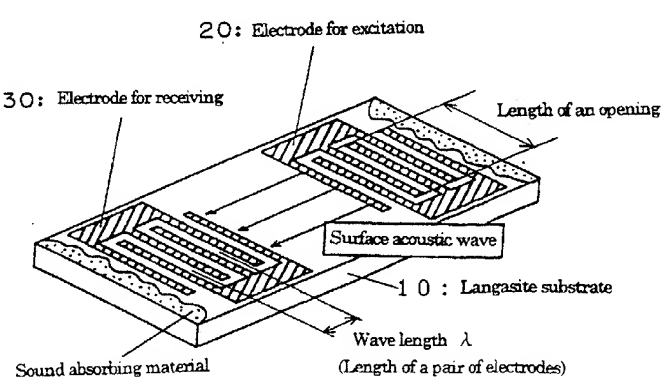
(54) Surface acoustic wave element

(57) The present invention relates to a surface acoustic wave element used in an element or the like of a filter for selecting frequency used in a communication device or the like, a resonator used in a highly stabilized oscillator or the like, with an object of providing a surface acoustic wave element having a small temperature coefficient of delay and a comparatively large electromechanical coupling coefficient and having a chemically stable substrate material, in which a langasite substrate is used and when a cut-out angle from langasite single crystal and a direction of propagating a surface acoustic wave are $(180°+\alpha, 40°+\beta, 20°+\gamma)$ in Eulerian angles expression, α=-2° through +6°, β=-4° through +9°, γ=-1° through +9°, or α=-6° through 6°, β=-5° through 5°, γ=-5° through 5° in the case of $(9°+\alpha, 150°+\beta, 37°+\gamma)$, or α=-5° through 5°, β=-5° through 5°, γ=-5° through 5° in the case of $(0°+\alpha, 140°+\beta, 24°+\gamma)$ or orientations equivalent thereto.

FIG.1



Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a surface acoustic wave element used in an element or the like of a filter for selecting frequency used in a communication device, a resonator used in an oscillator with high stability and so on.

Description of the Related Art

Conventionally, as a substrate for a surface acoustic wave element, there has generally been used a substrate produced by cutting and polishing a piezoelectric single crystal of lithium niobate, lithium tantalate, lithium tetraborate (for example, refer to Japanese Unexamined Patent Publication No. JP-A-60-41315), crystallized quartz or the like by a pertinent cut face.

As functions which are important in a piezoelectric substrate used in a surface acoustic wave element, a Temperature Coefficient of a Delay (TCD) and an Electromechanical Coupling Coefficient (K^2) are pointed out. The nearer the TCD to null and the larger the K^2, the more preferable are these coefficients for a substrate for a surface acoustic wave element. Conventionally, as a substrate for a surface acoustic wave element, there has generally been used a substrate produced by cutting and polishing a piezoelectric single crystal of lithium niobate ($LiNbO_3$), lithium tantalate ($LiTaO_3$), lithium tetraborate ($Li_2B_4O_7$), crystallized quartz or the like by a pertinent cut face. In the case of $LiNbO_3$ (for example, 128° Y cut - X propagation), although K^2 is as large as 5.5 %, TCD is as large as 74 ppm/°C and accordingly, drift of frequency caused by temperature change is caused and the substrate cannot be used in a filter requiring a narrow band characteristic, an oscillator requiring a highly stabilized accuracy and the like. Further, in the case of $Li_2B_4O_7$ (for example, 45° X cut - Z propagation), although K^2 is 1 % and TCD is 0 ppm/°C, the substrate is dissolved in water and it bears a deliquescence property and accordingly, processing thereof is difficult and reliability is deteriorated. Further, although ST cut crystallized quartz is provided with null TCD, K^2 is as small as 0.1 % and therefore, a filter having a wide band cannot be obtained.

From a request for a surface acoustic wave element having a higher function and figher-frequency performance, a substrate material where TCD is near to null and the larger K^2 is obtained and which is chemically stable has been required.

SUMMARY OF THE INVENTION

In view of the above-described situation, it is an object of the present invention to provide a surface acoustic wave element having small TCD and comparatively large K^2 and having a chemically stable substrate material.

According to a first aspect of the present invention to achieve the above-described object, there is provided a surface acoustic wave element in which a metal film for exciting, receiving or reflecting a surface acoustic wave is formed on a substrate of langasite ($La_3Ga_5SiO_{14}$) single crystal, wherein when a cut-out angle from the single crystal of the langasite substrate and a direction of propagating the surface acoustic wave are designated by (180°+α, 40°+β, 20°+γ) in Eulerian angles (Euler angles) expression, α=-2° through +6°, β=-4° through +9°, γ=-1° through +9° or an orientation equivalent thereto.

Further, according to a second aspect of the present invention to achieve the above-described object, there is provided a surface acoustic wave element in which a metal thin film for exciting, receiving or reflecting a surface acoustic wave is formed on a substrate of langasite ($La_3Ga_5SiO_{14}$) single crystal, wherein when a cut-out angle from the single crystal of the langasite substrate and a direction of propagating the surface acoustic wave are designated by (9°+α, 150°+β, 37°+γ) in Eulerian angles expression, α=-6° through 6°, β=-5° through 5°, γ=-5° through 5° or an orientation equivalent thereto.

Here, according to the surface acoustic wave element of the second aspect of the present invention, it is particularly preferable that the cut-out angle from the single crystal of the langasite substrate and the direction of propagating the surface acoustic wave are (13.4°, 150.5°, 37.2°) in Eulerian angles expression or an orientation equivalent thereto.

Further, according to a third aspect of the present invention to achieve the above-described object, there is provided a surface acoustic wave element in which a metal thin film for exciting, receiving or reflecting a surface acoustic wave is formed on a substrate of langasite ($La_3Ga_5SiO_{14}$) single crystal, wherein when a cut-out angle from the single crystal of the langasite substrate and a direction of propagating the surface acoustic wave are designated by (0°+α, 140°+β, 24°+γ) in Eulerian angles expression, α=-5° through 5°, β=-5° through 5°, γ=-5° through 5° or an orientation equivalent thereto.

According to the surface acoustic wave element of the third aspect of the present invention, it is particularly prefer-

able that the cut-out angle from the single crystal of the langasite substrate and the direction of propagating the surface acoustic wave are (0°, 140°, 24°) in Eulerian angles expression or an orientation equivalent thereto.

The inventors have achieved the present invention by discovering that a surface acoustic wave element in which a metal film is formed in a propagation orientation at a specific cut face of langasite ($La_3Ga_5SiO_{14}$) which is a single crystal having a piezoelectric performance, is provided with a small temperature coefficient of delay and a comparatively large electromechanical coupling coefficient and is chemically stable.

According to the present invention, there is provided a surface acoustic wave element having a small temperature coefficient of delay and a comparatively large electromechanical coupling coefficient and having a chemically stable substrate material.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view of a transmission type SAW (Surface Acoustic Wave) filter;
Fig. 2 shows a graph indicating changes in K^2 and TCD of a cut face of (175°-185°, 40°, 20°);
Fig. 3 shows a graph indicating changes in K^2 and TCD of a cut face of (180°, 35°-45°, 20°);
Fig. 4 shows a graph indicating changes in K^2 and TCD of a cut face of (180°, 40°, 15°-25°);
Fig. 5 shows a graph indicating temperature dependency of a central frequency;
Fig. 6 shows a graph indicating changes in K^2 and TCD of a cut face of (3°-15°, 150.5°, 37.2°);
Fig. 7 shows a graph indicating changes in K^2 and TCD of a cut face of (10°, 146°-156°, 37.2°);
Fig. 8 shows a graph indicating changes in K^2 and TCD of a cut face of (10°, 150.5°, 32°-42°);
Fig. 9 shows a graph indicating temperature dependency of a central frequency;
Fig. 10 shows a graph indicating changes in K^2 and TCD of a cut face of (-5°-5°, 140°, 24°);
Fig. 11 shows a graph indicating changes in K^2 and TCD of a cut face of (0°, 135°-145°, 24°);
Fig. 12 shows a graph indicating changes in K^2 and TCD of a cut face of (0°, 140°, 19°-29°); and
Fig. 13 shows a graph indicating temperature dependency of a central frequency.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a schematic view of a transmission type SAW filter.

When a pair of comb-like electrodes are formed on a langasite single crystal substrate 10 and a high frequency voltage is applied on one of these (electrode for excitation 20), a surface acoustic wave is excited and reaches a receiving electrode 30. A band-pass filter characteristic is produced in the frequency characteristic between an input and an output of these and a temperature characteristic of the filter is determined by a property of the piezoelectric crystal.

As constants necessary for calculating the characteristic of the surface acoustic wave on the langasite single crystal, there are shown a density, an elastic constant, a piezoelectric constant, a dielectric constant and a linear expansion coefficient at 20 °C in Table 1 shown below.

Further, Table 2 shows primary and secondary temperature coefficients thereof.

Table 1

Various constants of langasite used in calculation		
Measured temperature °C		20
Density ρ (Kg/m^3)		5764
Elastic constant, C^E ($10^{10}N/m^2$)	C^E_{11}	18.93
	C^E_{12}	10.50
	C^E_{13}	9.528
	C^E_{14}	1.493
	C^E_{33}	26.24
	C^E_{44}	5.384
	C^E_{66}	4.216
Piezoelectric constant, e (C/m^2)	e_{11}	-0.431
	e_{14}	0.108

Table 1 (continued)

Various constants of langasite used in calculation		
Dielectric constant, $\varepsilon^T/\varepsilon^0$	$\varepsilon^T_{11}/\varepsilon^0$	18.97
	$\varepsilon^T_{33}/\varepsilon^0$	52.00
Linear expansion coefficient, λ (10^{-6}/K)	λ_{11}	5.07
	λ_{33}	3.60

Table 2

Temperature coefficients of respective constants of langasite used in calculation			
Measured temperature°C		20	
		Primary coefficient (10^{-5}/K)	Secondary coefficient (10^{-9}/K)
Elastic constant, C^E (10^{10}N/m^2)	C^E_{11}	-53	-4.2
	C^E_{12}	-92	+25
	C^E_{13}	-88	-131
	C^E_{14}	-205	+870
	C^E_{33}	-104	-109
	C^E_{44}	-62	-111
	C^E_{66}	-4.7	-40.7
Piezoelectric constant, e (C/m^2)	e_{11}	456	1032
	e_{14}	-628	1480
Dielectric constant, $\varepsilon^T/\varepsilon^0$	$\varepsilon^T_{11}/\varepsilon^0$	137	82
	$\varepsilon^T_{33}/\varepsilon^0$	-795	1076

An explanation will firstly be given of a first embodiment of the present invention as follows.

Here, it is found that as ranges of angles whereby the absolute value of TCD having 5 ppm or less and the electro-mechanical coupling coefficient K^2 having 0.3 % or more are obtained, α=-2° through +6°, β=-4° through +9°, γ=-1° through +9° or orientations equivalent thereto are preferable when Eulerian angles expression are designated by (180°+α, 40°+β, 20°+γ), by simultaneously solving Newton's equation of motion, equation of piezoelectricity and quasi-electrostatically approximated Maxwell's equation at the surface of the piezoelectric substrate by using the constants shown by Table 1 and Table 2 (refer to Fig. 2 through Fig. 4).

$$TCD = \gamma - (1/V)\,(\partial V/\partial T) \qquad (1)$$

V: Sound speed of surface acoustic wave at temperature T=25°C,
T: Temperature,
γ: Thermal expansion coefficient of cut face propagation direction under consideration.

Here, as a film thickness h of an electrode material, when a wavelength of a surface acoustic wave is designated by notation λ, a range of h/λ=0.005 through 0.2 is preferable. Further, aluminum is suitable as an electrode material, as other materials, gold may be used, aluminum + titanium may be used, or aluminum + copper is also suitable.

A pattern of the transmission type surface acoustic wave filter shown by the schematic view of Fig. 1 is formed by a photolithography step in a cut face and a propagation direction represented by (180°, 140°, 20°) in Eulerian angles expression.

In this case, a line width and a line interval of the comb-like electrodes are respectively 4 μm, numbers of pairs of

electrodes on input and output sides are respectively 30 pairs and a length of an opening of the comb-like electrode is 400 μm. Aluminum is used as the material of the electrode and the film thickness is constituted to 2400 Angstrom (h/λ=1.5 %) by a sputtering process. The element is mounted onto a metal package and the comb-like electrodes for transmission and reception are led out by a wire bonding and connected to a network analyzer. Further, when the device is put into a thermostat and a change of a central frequency is measured in a temperature range of -20°C through 80°C, a characteristic shown by Fig. 5 is obtained and it is confirmed that TCD(=-TCF)=3 ppm/°C at 25°C.

Next, an explanation will be given of a second embodiment of the present invention.

Here, it is found that as ranges of angles whereby the absolute value of TCD having 7 ppm or less and the electromechanical coupling coefficient K^2 having 0.1 % or more are obtained, α=-6° through 6°, β=-5° through 5°, γ=-5° through 5° or orientations equivalent thereto are preferable when Euleraian angles expression are designated by (9°+α, 150°+β, 37°+λ), by simultaneously solving Newton's equation of motion, equation of piezoelectricity and quasi- electrostatically approximated Maxwell's equation at the surface of the piezoelectric substrate by using the constants shown in Table 1 and Table 2. As a result of a further detailed investigation, it is found that in the case of (13.4°, 150.5°, 37.2°) in Eulerian angles expression or orientations equivalent thereto, TCD=0 ppm/°C and K^2=0.45 % and the orientations are preferable (refer to Fig. 6 through Fig. 8).

Here, TCD is represented by Equation (1), mentioned above. Also, similar to the above-described first embodiment, in respect of the film thickness h of electrode material, when the wavelength of the surface acoustic wave is designated by notation λ, a range of h/λ=0.005 through 0.2 is preferable. Further, aluminum is suitable as electrode material, as other material, gold may be used, aluminum + titanium may be used or aluminum + copper is also suitable.

A pattern of the transmission type surface acoustic wave filter shown by the schematic view of Fig. 1 is formed by a photolithography step in a cut face and a propagation direction represented by (13.4°, 150.5°, 37.2°) in Eulerian angles expression.

In this case, a line width and a line interval of the comb-like electrodes are respectively 4 μm, numbers of pairs of the electrodes on input and output sides are respectively 30 pairs and a length of an opening of the comb-like electrode is 400 μm. Aluminum is used as the material of the electrode and the film thickness is constituted to 2400 Angstrom (h/λ=1.5 %) by a sputtering process. The element is mounted onto a metal package and the comb-like electrodes for transmission and reception are led out by a wire bonding and connected to a network analyzer. Further, when the device is put into a thermostat and the change of a central frequency is measured in a temperature range of -20°C through 80°C, a characteristic shown by Fig. 9 is obtained and it is confirmed that TCD(=-TCF) is substantially 0 ppm/°C at 25°C.

Next, an explanation will be given of a third embodiment of the present invention.

Here, by solving simultaneously Newton's equation of motion, equation of piezoelectricity and quasi-electrostatically approximated Maxwell's equation at the surface of piezoelectric substrate by using the constants shown by Table 1 and Table 2, it is found that the absolute value of TCD at temperature of 25°C is 5 ppm/°C or less and the electromechanical coupling coefficient K^2 is 0.3 % or more in a range of (-5° through 5°, 140°, 24°) (refer to Fig. 10), a range of (0°, 135° through 145°, 24°) (refer to Fig. 11), and a range of (0°, 140°, 19° through 29°) (refer to Fig. 12) or ranges of orientations equivalent to these ranges in Eulerian angles expression. As a result of further detailed investigation, it is found that TCD=0 ppm/°C and K^2=0.375 % are obtained in the case of(0°, 140°, 24°) in Eulerian angles expression or orientations equivalent thereto, which are preferable orientations for a SAW (surface acoustic wave) device. In this case, TCD is expressed by Equation (1), mentioned above.

Further, similar to the above-described cases of the first embodiment and the second embodiment, in respect of the film thickness h of the material of the electrode, when the wavelength of the surface acoustic wave is designated by notation λ, a range of h/λ=0.005 through 0.2 is preferable. Further, aluminum is suitable as the material of the electrode, as other material, gold may be used, aluminum+titanium may be used, or aluminum+copper is suitable. Further, metals of molybdenum, tungsten and the like are widely suitable.

A pattern of the transmission type surface acoustic wave filter shown by the schematic view of Fig. 1 is formed by a photolithography step in a cut face and a propagation direction represented by (0°, 140°, 24°) in Eulerian angles expression.

In this case, a line width and a line interval of the comb-like electrodes are respectively 4 μm, numbers of couples of electrodes on input and output sides are respectively 30 pairs and a length of an opening of the comb-like electrode is 400 μm. Aluminum is used as the material of the electrode and the film thickness is constituted to 2400 Angstrom (h/λ=1.5 %) by a sputtering process. The element is mounted onto a metal package and the comb-like electrodes for transmission and reception are led out by a wire bonding and connected to a network analyzer. Further, when the device is put into a thermostat and a change of a central frequency is measured in a temperature range of -20°C through 80°C, a characteristic shown by Fig. 13 is obtained and it is confirmed that TCD(=-TCF) at 25°C is substantially 0 ppm/°C.

Claims

1. A surface acoustic wave element in which a metal film for exciting, receiving or reflecting a surface acoustic wave is formed on a substrate of langasite ($La_3Ga_5SiO_{14}$) single crystal, wherein when a cut-out angle from the single crystal of the langasite substrate and a direction of propagating the surface acoustic wave are designated by (180°+α, 40°+β, 20°+γ) in Eulerian angles expression, α=-2° through +6°, β=-4° through +9°, γ=-1° through +9° or an orientation equivalent thereto.

2. A surface acoustic wave element in which a metal film for exciting, receiving or reflecting a surface acoustic wave is formed on a substrate of langasite ($La_3Ga_5SiO_{14}$) single crystal, wherein when a cut-out angle from the single crystal of the langasite substrate and a direction of propagating the surface acoustic wave are designated by (9°+α, 150°+β, 37°+γ) in Eulerian angles expression, α=-6° through 6°, β=-5° through 5°, γ=-5° through 5° or an orientation equivalent thereto.

3. The surface acoustic wave element according to Claim 2, wherein the cut-out angle from the single crystal of the langasite substrate and the direction of propagating the surface acoustic wave are (13.4°, 150.5°, 37.2°) in Eulerian angles expression or an orientation equivalent thereto.

4. A surface acoustic wave element in which a metal film for exciting, receiving or reflecting a surface acoustic wave is formed on a substrate of langasite ($La_3Ga_5SiO_{14}$) single crystal, wherein when a cut-out angle from the single crystal of the langasite substrate and a direction of propagating the surface acoustic wave are designated by (0°+α, 140°+β, 24°+γ) in Eulerian angles expression, α=-5° through 5°, β=-5° through 5°, γ=-5° through 5° or an orientation equivalent thereto.

5. The surface acoustic wave element according to Claim 4, wherein the cut-out angle from the single crystal of the langasite substrate and the direction of propagating the surface acoustic wave are (0°, 140°, 24°) in Eulerian angles expression or an orientation equivalent thereto.

FIG.1

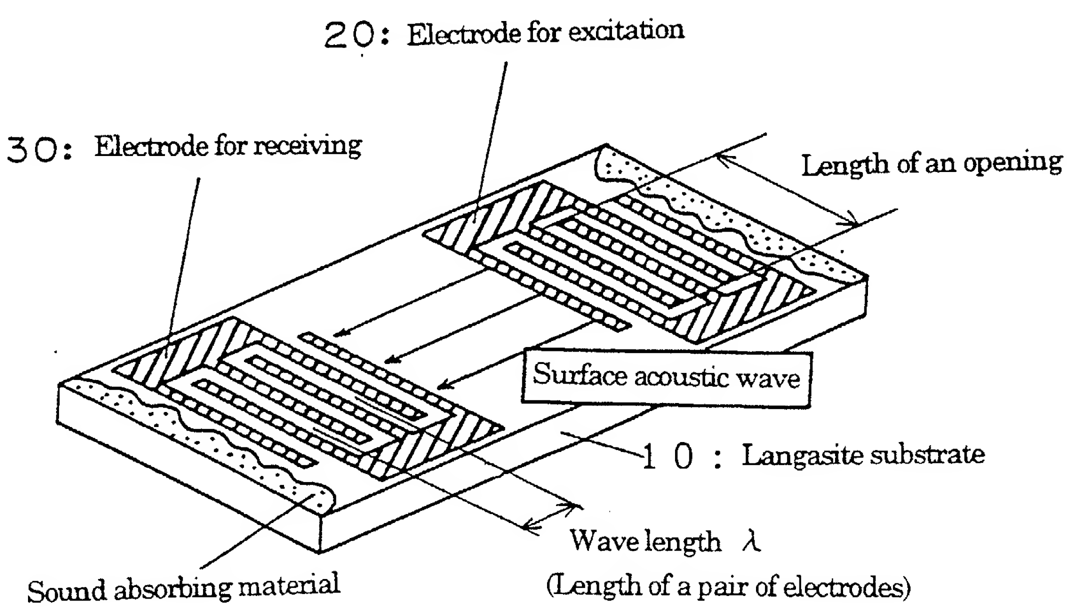
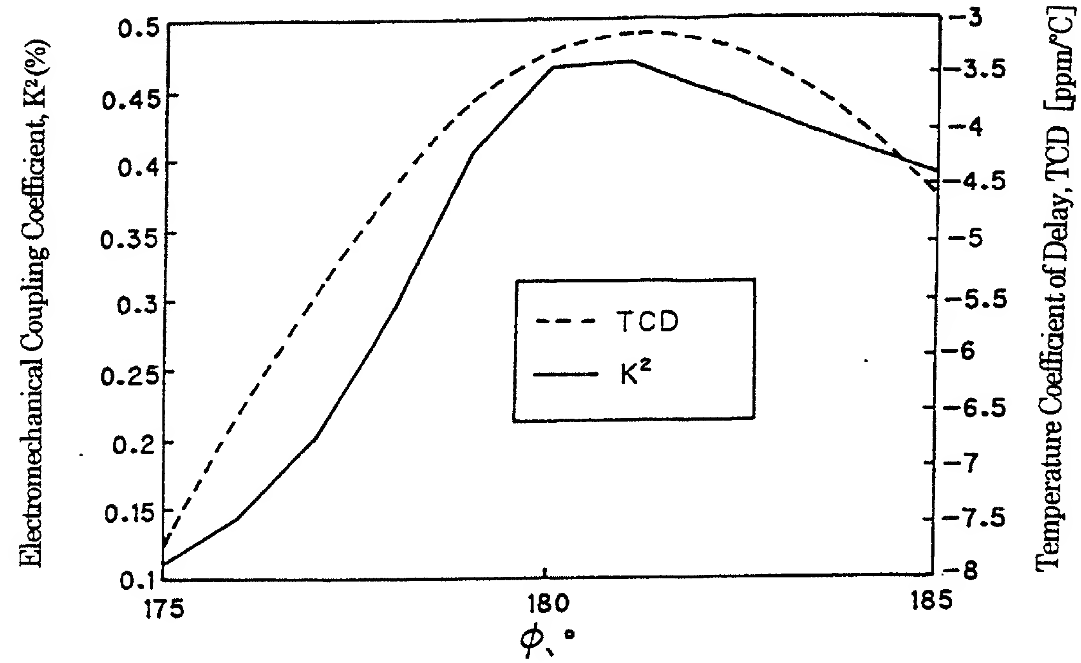
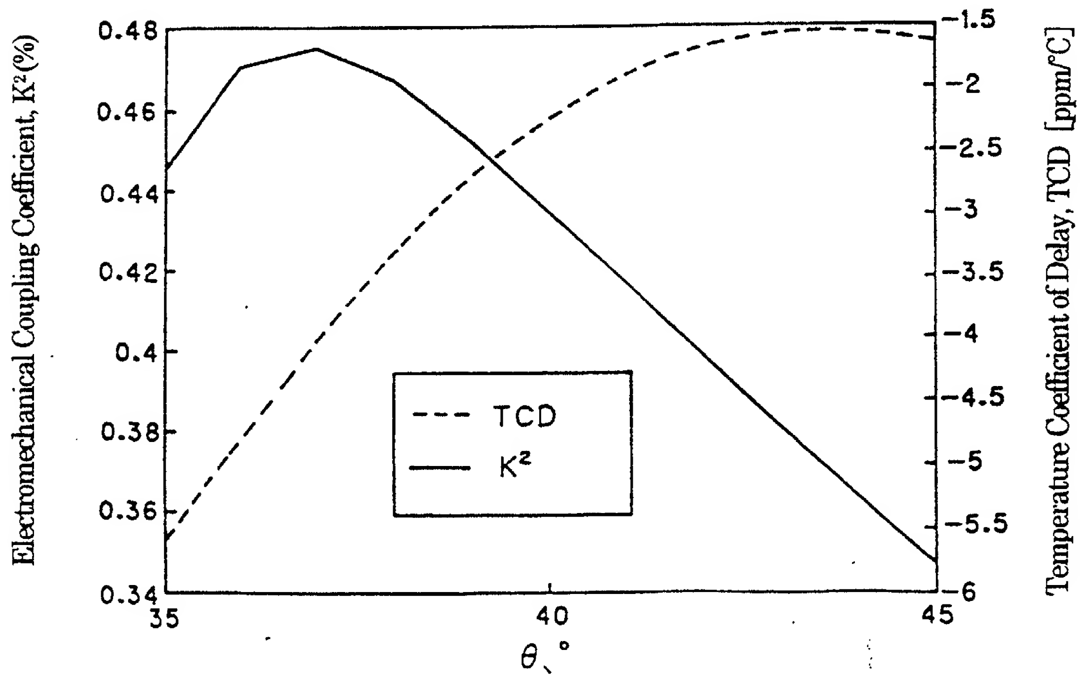

20: Electrode for excitation
30: Electrode for receiving
Length of an opening
Surface acoustic wave
1 0 : Langasite substrate
Wave length λ
(Length of a pair of electrodes)
Sound absorbing material

FIG.2



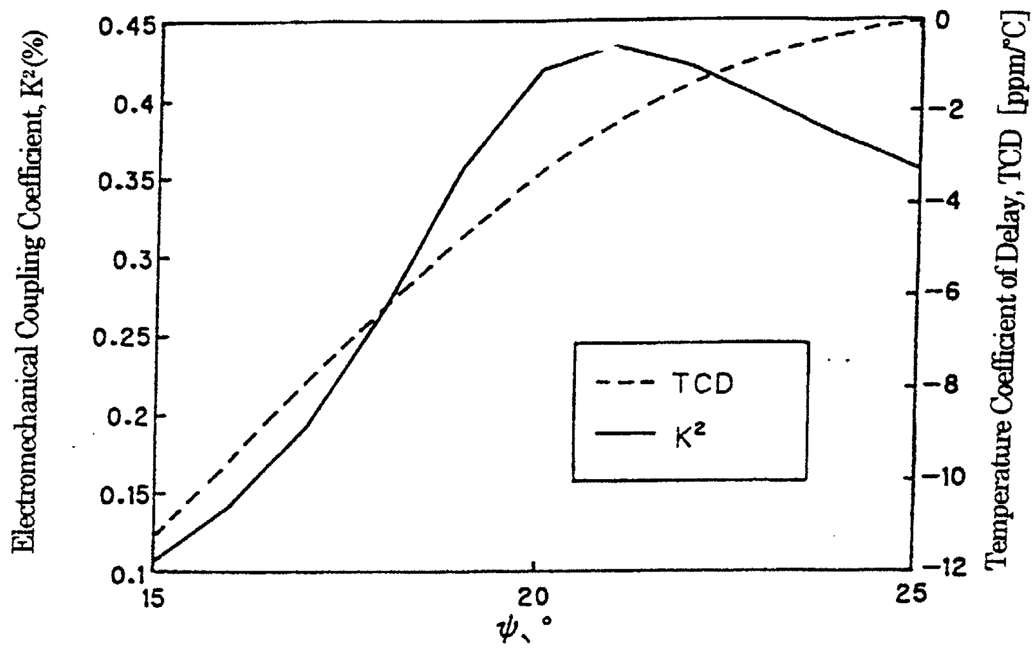
Changes in K^2 and TCD of a cut face of (175° ~185°, 40°, 20°)

FIG.3



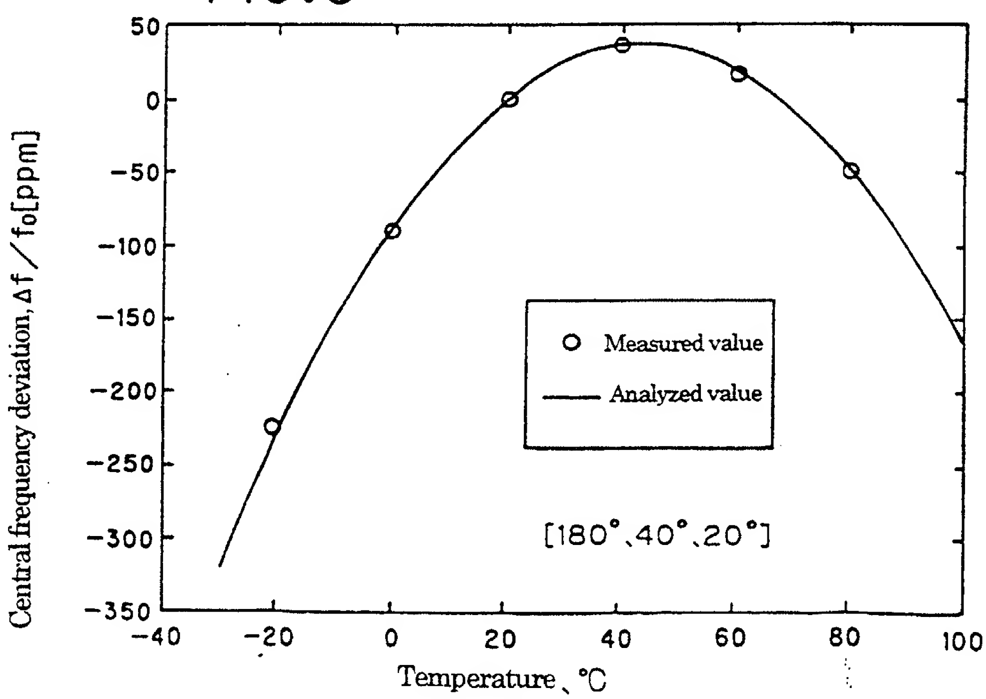
Changes in K^2 and TCD of a cut face of (180°, 35° ~45°, 20°)

FIG.4



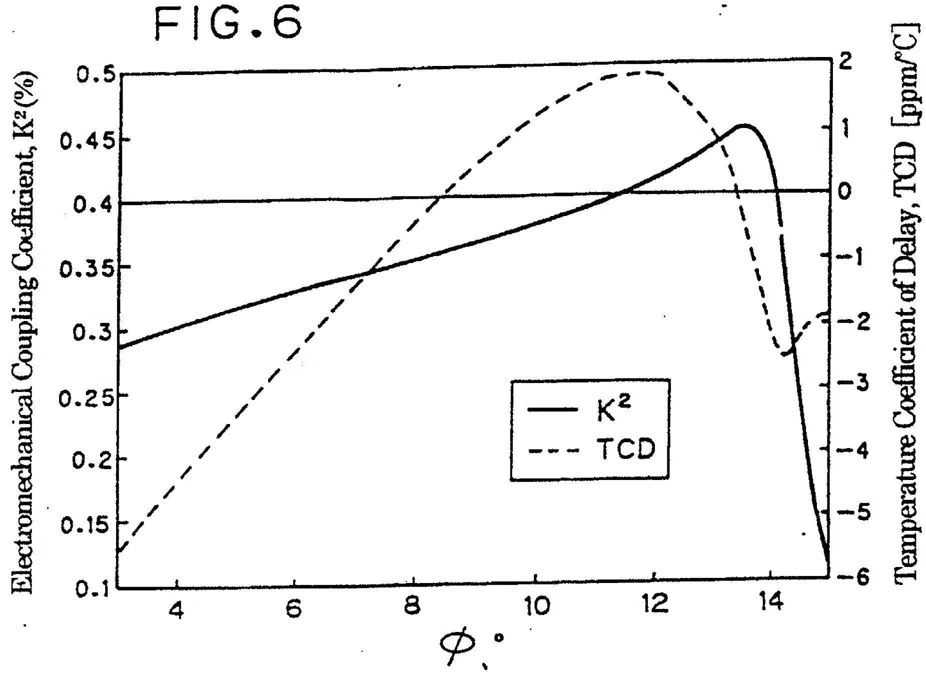
Changes in K^2 and TCD of a cut face of (180°, 40°, 15°~25°)

FIG.5



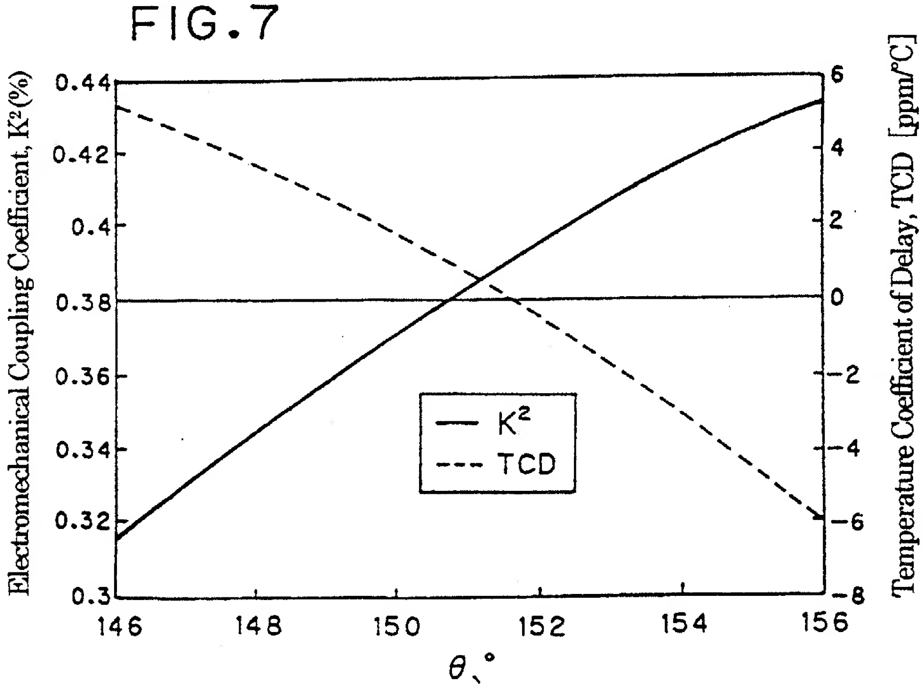
Temperature dependency of a central frequency
(Central frequency when f_0 is at 20°C)

FIG.6



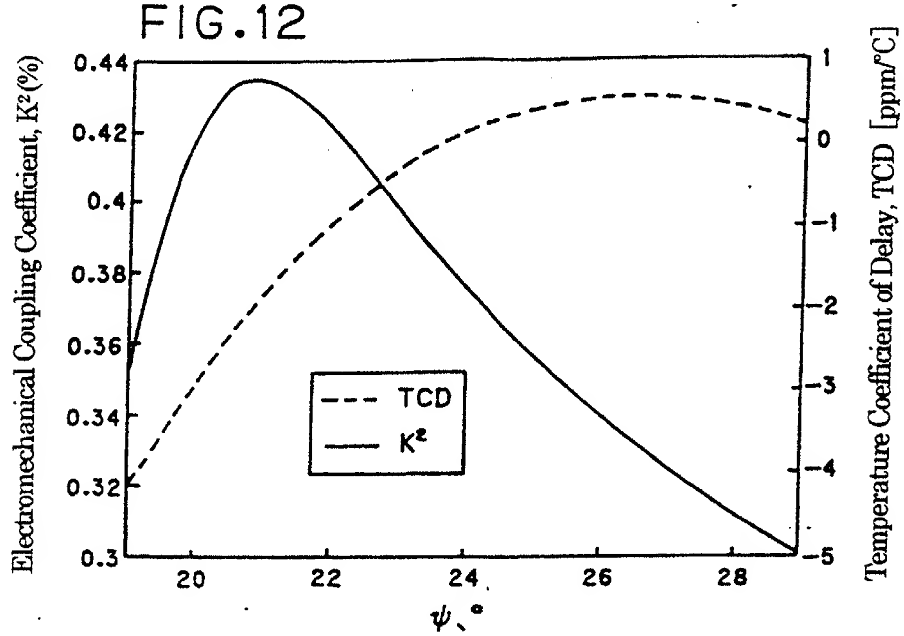
Changes in K^2 and TCD of a cut face of $(3\sim15^\circ, 150.5^\circ, 37.2^\circ)$

FIG.7



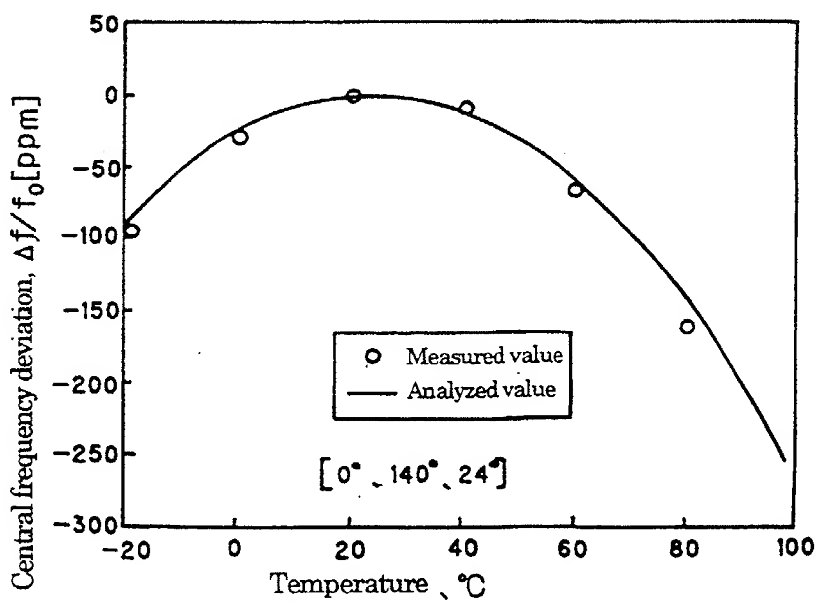
Changes in K^2 and TCD of a cut face of $(10^\circ, 146\sim156^\circ, 37.2^\circ)$

FIG.12



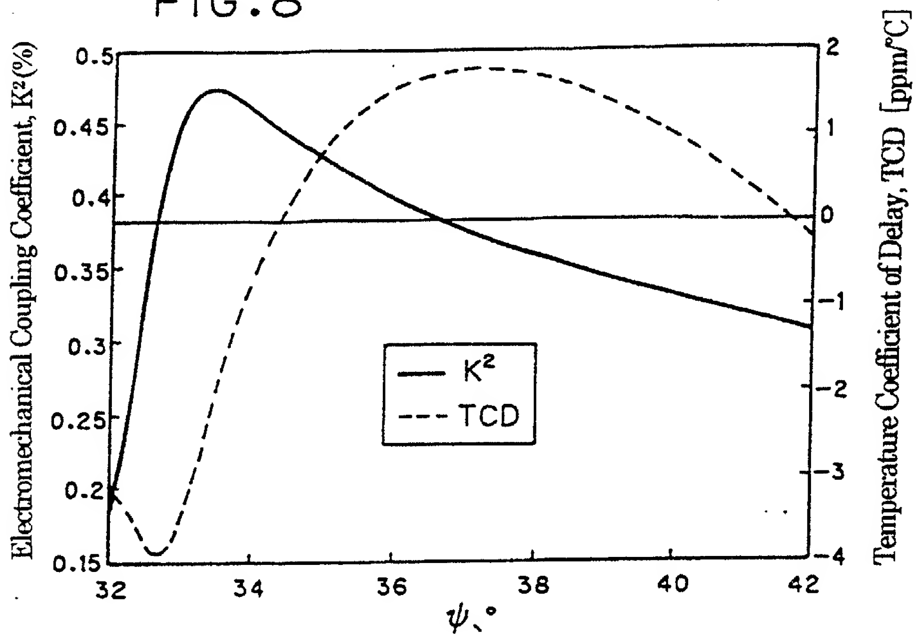
Changes in K^2 and TCD of a cut face of (0°, 140°, 19°~ 29°)

FIG.13



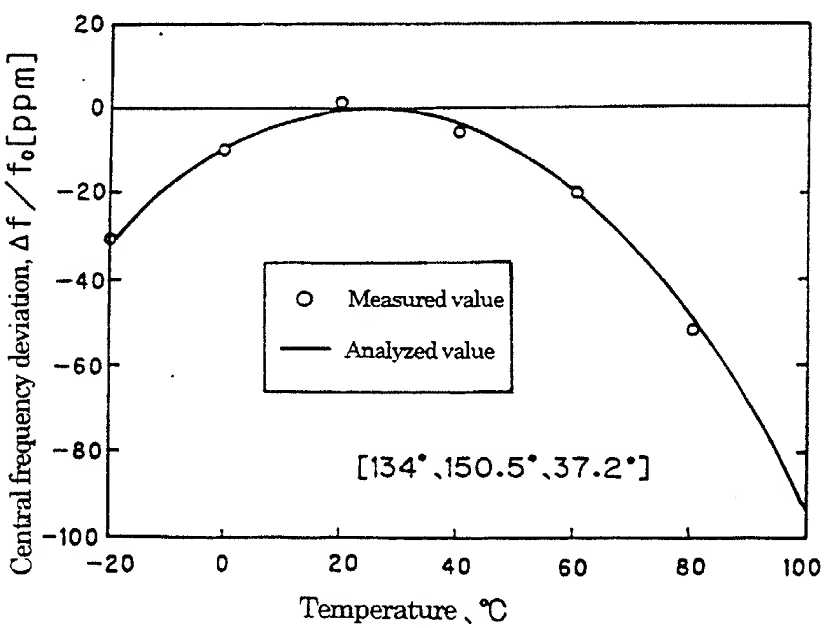
Temperature dependency of a central frequency
(Central frequency when f_0 is at 25°C)

FIG.8



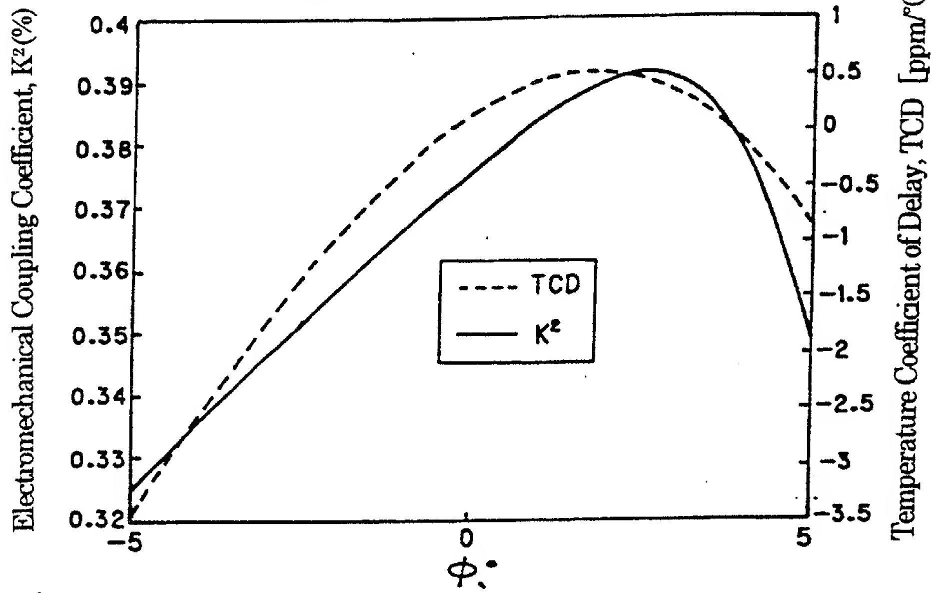
Changes in K^2 and TCD of a cut face of (10°、150°、32∼42°)

FIG.9



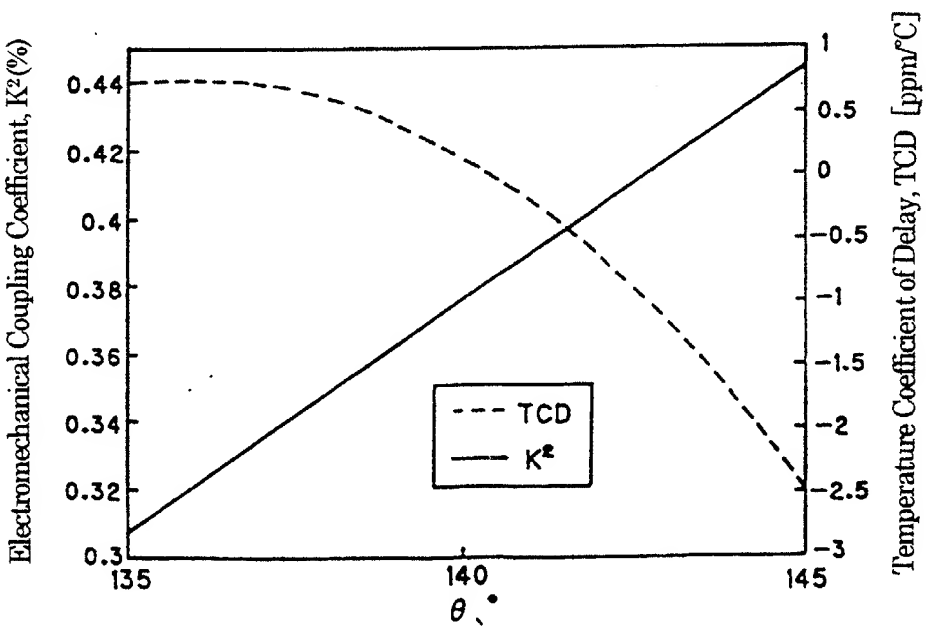
Temperature dependency of a central frequency
(Central frequency when f_0 is at 25°C)

FIG.10



Changes in K^2 and TCD of a cut face of (−5°~5°, 140°, 24°)

FIG.11



Changes in K^2 and TCD of a cut face of (0°, 135°~145°, 24°)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 866 551 A3

(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:
24.05.2000 Bulletin 2000/21

(51) Int. Cl.^{7}: **H03H 9/02**

(43) Date of publication A2:
23.09.1998 Bulletin 1998/39

(21) Application number: **98104212.0**

(22) Date of filing: **10.03.1998**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **21.03.1997 JP 6837097**
24.03.1997 JP 6962097
02.07.1997 JP 17714497

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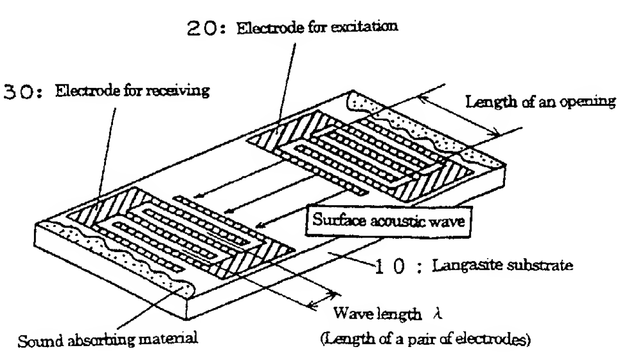
(54) **Surface acoustic wave element**

(57) The present invention relates to a surface acoustic wave element used in an element or the like of a filter for selecting frequency used in a communication device or the like, a resonator used in a highly stabilized oscillator or the like, with an object of providing a surface acoustic wave element having a small temperature coefficient of delay and a comparatively large electromechanical coupling coefficient and having a chemically stable substrate material, in which a langasite substrate is used and when a cut-out angle from langasite single crystal and a direction of propagating a surface acoustic wave are (180°+α, 40°+β, 20°+γ) in Eulerian angles expression, α=-2° through +6°, β=-4° through +9°, γ=-1° through +9°, or α=-6° through 6°, β=-5° through 5°, γ=-5° through 5° in the case of (9°+α, 150°+β, 37°+γ), or α=-5° through 5°, β=-5° through 5°, γ=-5° through 5° in the case of (0°+α, 140°+β, 24°+γ) or orientations equivalent thereto.

FIG.1



EP 0 866 551 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 98 10 4212

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	YAKOVKIN I B ET AL: "Numerical and experimental investigation SAW in langasite" 1995 IEEE ULTRASONICS SYMPOSIUM. PROCEEDINGS. AN INTERNATIONAL SYMPOSIUM (CAT. NO.95CH35844), 1995 IEEE ULTRASONICS SYMPOSIUM. PROCEEDINGS. AN INTERNATIONAL SYMPOSIUM, SEATTLE, WA, USA, 7-10 NOV. 1995, pages 389-392 vol.1, XP002112466 1995, New York, NY, USA, IEEE, USA ISBN: 0-7803-2940-6 * page 3896, left-hand column, line 34 - page 390, left-hand column, line 4; figures *	1,2,4	H03H9/02
A	DUBOVNIK M F ET AL: "LANGASITE (LA3GA5SI014) AN OPTICAL PIEZOELECTRIC: GROWTH AND PROPERTIES" PROCEEDINGS OF THE INTERNATIONAL FREQUENCY CONTROL SYMPOSIUM,US,NEW YORK, IEEE, vol. SYMP. 48, page 43-47 XP000674152 ISBN: 0-7803-1946-X * page 45, right-hand column, line 64 - page 46, left-hand column, line 14 *	1,2,4	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H03H
A	N.F. NAUMENKO: "SAW and leaky waves in a new piezoelectric crystal of langasite" NATIONAL CONFERENCE ON ACOUSTOELECTRONICS. 1994 INTERNATIONAL SYMPOSIUM ON PROGRAM AND ABSTRACTS, 17 - 23 May 1994, page 111 XP002124723 * the whole document *	1,2,4	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 March 2000	D/L PINTA BALLE.., L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 4212

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	SAKHAROV S ET AL: "New data on temperature stability and acoustical losses of langasite crystals" PROCEEDINGS OF THE 1995 IEEE INTERNATIONAL FREQUENCY CONTROL SYMPOSIUM. (THE 49TH ANNUAL SYMPOSIUM) (CAT.NO.95CH35752), PROCEEDINGS OF THE 1995 IEEE INTERNATIONAL FREQUENCY CONTROL SYMPOSIUM (49TH ANNUAL SYMPOSIUM), SAN FRANCISCO, CA, USA, 31 MAY-2 J, pages 647-652, XP000848280 1995, New York, NY, USA, IEEE, USA ISBN: 0-7803-2500-1 * page 649, right-hand column, line 36 - page 650, line 29; figures 1,2 * -----	1,2,4	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 March 2000	D/L PINTA BALLE.., L

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EPO FORM 1503 03 82 (P04C01)

European Patent Office

Application Number
EP 98 10 4212

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

European Patent Office

LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 98 10 4212

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claim : 1

   SAW element comprising a substrate of langasite crystal cut out with a first orientation

2. Claim : 2 3

   SAW element comprising a substrate of langasite crystal cut out with a second orientation

3. Claim : 4 5

   SAW element comprising a substrate of langasite crystal cut out with a third orientation